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Modifications to LLNL Plutonium Packaging System (PuPS) to Achieve ASME VIII UW-13.2(d) Requirements for the DOE Standard 3013-00 Outer Can Weld

D. Riley, K. Dodson

U.S. Department of Energy

Lawrence Livermore National Laboratory

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DISCLAIMER

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By
David Riley (SAIC)
Karen Dodson (LLNL)

Summary

The Lawrence Livermore National Laboratory (LLNL) Plutonium Packaging System (PuPS) prepares packages to meet the DOE Standard 3013 (Reference 1). The PuPS equipment was supplied by the British Nuclear Fuels Limited (BNFL). The DOE Standard 3013 requires that the welding of the Outer Can meets ASME Section VIII Division 1 (Reference 2). ASME Section VIII references to ASME Section IX (Reference 3) for most of the welding requirements, but UW-13.2 (d) of Section VIII requires a certain depth and width of the weld (see Figure 1).

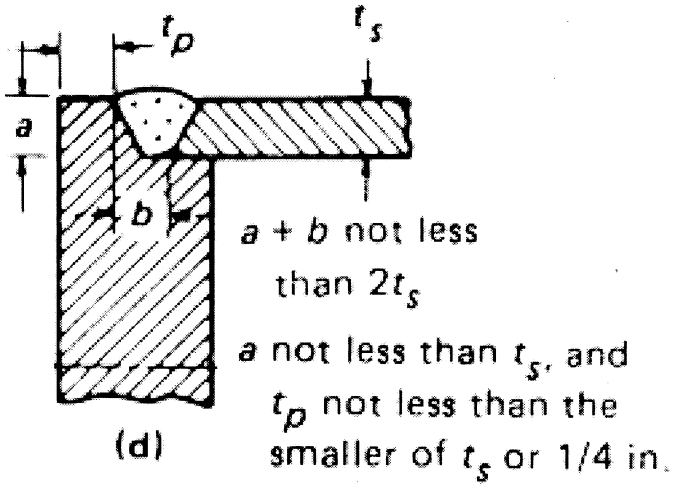


Figure 1

Where:

- a = Depth of weld - lid radial surface to bottom of weld.
- b = Weld width - Position of weld cap toe on lid radial surface to opposite point of weld intersection with lid radial recess/can interface.
- t_s = Can wall thickness.

In this document the UW-13.2(d) requirement is described as the $(a+b)/2t_s$ ratio. This ratio has to be greater than or equal to one to meet the requirements of UW-13.2(d). The Outer Can welds had not been meeting this requirement. Three methods are being followed to resolve this issue:

1) Modify the welding parameters to achieve the requirement,

2) Submit a weld case to ASME that changes the UW-13.2(d) requirement for their review and approval, and
3) Change the requirements in the DOE-STD-3013.

Each of these methods are being pursued. This report addresses how the first method was addressed for the LLNL PuPS. The experimental work involved adjusting the Outer Can rotational speed and the power applied to the can. These adjustments resulted in being able to achieve the ASME VIII, UW-13.2(d) requirement.

Experimental Work

BNFL assisted LLNL in determining how to adjust the welding parameters. An agreed upon Outer Can Weld Test Plan was developed with interactions of BNFL, SRS and LLNL personnel. The proposed runs are summarized in Appendix A. BNFL personnel came to LLNL to assist with the implementation and completion of the plan. Savannah River Site also came to observe and assist with the testing. The testing occurred from November 14 -17, 2000, with additional work continuing afterwards. During this time we were able to complete the experiments laid out in the test plan and to complete additional experiments. Table 1 summarizes the cans that were welded and the parameters used. Appendix B contains the $(a+b)/2t_s$ ratios calculated for each sample of each can.

The general procedure was to weld three cans at each setting. The cans were welded with manual control of the timing. This was done to eliminate the need to change the control timers for each weld set. Two of the cans of each set were sectioned for metallographic examination and one was examined using radiography.

On Tuesday, 11/14/00, the current settings for the parameters of delivered laser power and rotational speed were determined to be 1637 Watts and 600 mm/min respectively. An Outer Can was welded with these initial welding parameters. The welding speed was then adjusted to about 580 mm/min and three cans were welded. Then the welding speed was adjusted to about 560 mm/min and three more cans were welded.

On Wednesday, 11/15/00, 540 and 520 mm/min runs were completed in the morning with three cans each. At lunchtime the results of the previous day were reviewed. The general consensus was to run a set of cans at the lower speed and higher wattage to see the effects. Therefore, in the afternoon, 560 and 540 mm/min runs were made at about 1750 W.

On Thursday, 11/16/00, the previous runs were reviewed. They showed that the $(a+b)/2t_s$ ratio was achieved but, the weld was slightly out of alignment with the joint. The locations of the rollers and the head alignment were adjusted. Then three more cans were run manually at 540 mm/min and 1750 W.

Table 1

Day	Activity	Test Samples	Can Rotation	Laser Power	Comments
Tuesday 11/14	1. Benchmark weld Outer Can	A000009	600 mm/min	1650 W	Verify current settings
	2. Complete Weld Testing at reduced can speed of 580 mm/min **(Manual Weld)**	A000010 A000012 A000017	580 mm/min	1650 W	Metallography Samples Metallography Sample Radiography Sample
	3. Complete Weld Testing at reduced can speed of 560 mm/min **(Manual Weld)**	A000083 A000086 R602242	560 mm/min	1650 W	Metallography Samples Metallography Sample Radiography Sample
Wednesday 11/15/00	1. Complete Weld Testing at reduced can speed of 540 mm/min **(Manual Weld)**	R602246 R602250 R602251	540 mm/min	1650 W	Metallography Samples Metallography Sample Radiography Sample
	2. Complete Weld Testing at reduced can speed of 520 mm/min **(Manual Weld)**	A000003 A000014 A000076	520 mm/min	1650 W	Metallography Samples Metallography Sample Radiography Sample
	3. Complete Weld Testing at reduced can speed of 560 mm/min and Higher Power (1750 W) **(Manual Weld)**	A000085 A000088 A000091	560 mm/min	1750 W	Metallography Samples Metallography Sample Radiography Sample
	4. Complete Weld Testing at reduced can speed of 540 mm/min and Higher Power (1750 W) **(Manual Weld)**	R602240 R602247 A000093	540 mm/min	1750 W	Metallography Samples Metallography Sample Radiography Sample
Thursday 11/16/00	1. Adjust alignment				
	2. Complete Weld Testing at reduced can speed of 540 mm/min and Higher Power (1750 W) **(Manual Weld)**	R602255 R602258 R602226	540 mm/min	1750 W	Metallography Samples Metallography Sample Radiography Sample
Friday 11/17/00	1. Adjust plume				
	2. Complete Weld Testing at can speed of 600 mm/min and Higher Power (1750 W) **(Automatic Weld)**	R602230 R602428	600 mm/min	1750 W	Metallography Samples Metallography Sample
Monday 11/20/00	Complete Weld Testing at reduced can speed and Higher Power. **(Automatic Weld)**	R602186 R602234	540 mm/min	1750 W	Metallography Samples Metallography Sample
Wednesday 11/29/00	Complete Weld Testing at reduced can speed and Higher Power. **(Automatic Weld)**	R602436	520 mm/min	1750 W	Metallography Samples

On Friday, 11/17/00, the control logic was adjusted to the new settings and two cans were run. The results showed that the (a+b)/2ts ratio was not achieved. Re-evaluation of the can rotation speed showed that the speed had reverted to 600 mm/min because the operator had not saved the settings into long term memory of the stepper motor controller. Therefore the settings had reverted to the original.

On Monday, 11/20/00, the can rotation speed was reset to 540 mm/min and two cans were welded. These samples achieved the required $(a+b)/2t_s$ ratio; however, three of the values were very close to one. Therefore, one additional can was welded at 520 mm/min. All of the samples from this weld have an $(a+b)/2t_s$ ratio were over one.

Analysis

The metallurgical samples of each can were taken at three locations ("Y", "X", and "O"). For the first three cans, the "Y", "X", and "O" were taken at the ramp-up, 180° from ramp-up and the overlap areas respectively. For the remaining cans, the "Y" location was a typical weld area. The "X" location was where the weld was the narrowest (expected location for the weld to be the deepest). The "O" location was in the middle of the weld overlap area. At each of these locations the weld was sliced out of the lid, etched and micrographed. The dimensions of a, b, and t_s were measured from the micrograph. These values were used to compute the $(a+b)/2t_s$ ratio at each location. For each can the maximum, minimum and average values of the $(a+b)/2t_s$ ratio were also computed. The data calculated from this work are presented in Appendix B. The effect of weld power and can rotational speed were plotted in Figures 2 (1650 Watts) and 3 (1750 Watts).

Conclusion

The ASME Section VIII UW-13.2 (d) requires the $(a+b)/2t_s$ ratio to be greater than one. The LLNL PuPS did not initially meet that requirement. After slowing down the welding speed to 520 mm/min and increasing the delivered power to 1750 W., the $(a+b)/2t_s$ ratio requirement was met. The PuPS control software has been modified to operate using these new welding parameters. LLNL will be performing additional runs to demonstrate operational reliability of the 520 mm/min and 1750 watt operation to achieve the $(a+b)/2t_s$ ratio greater than one

References

1) DOE STD 3013-00, "Stabilization, Packaging, and Storage of Plutonium Bearing Materials", U.S. Department of Energy, 2000.

2) ASME VIII, ASME Boiler and Pressure Vessel Code Section VIII, Div. 1(Rules for Construction of Pressure Vessels), 1998

3) ASME IX, ASME Boiler and Pressure Vessel Code Section IX (Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators), 1998

Figure 2

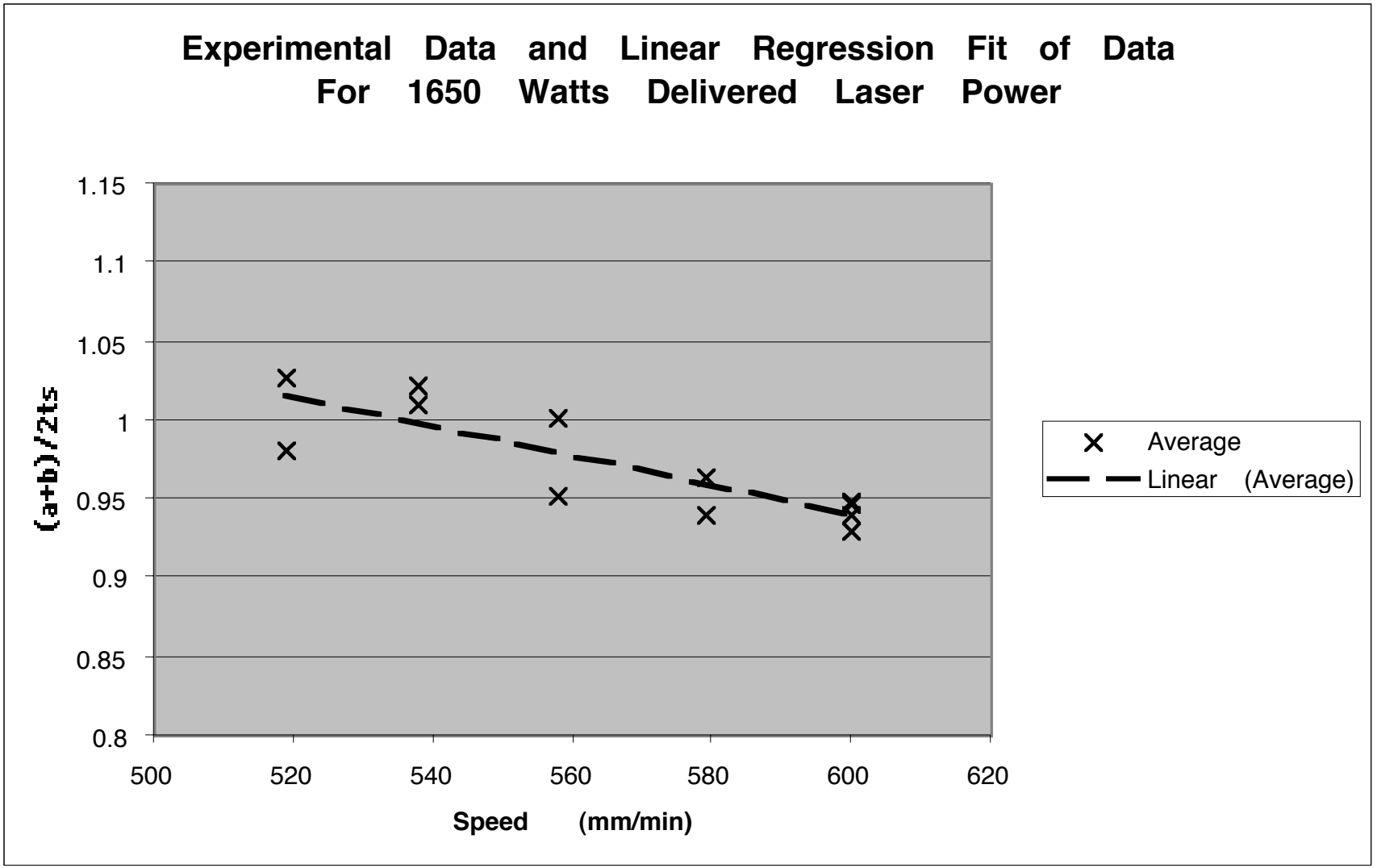
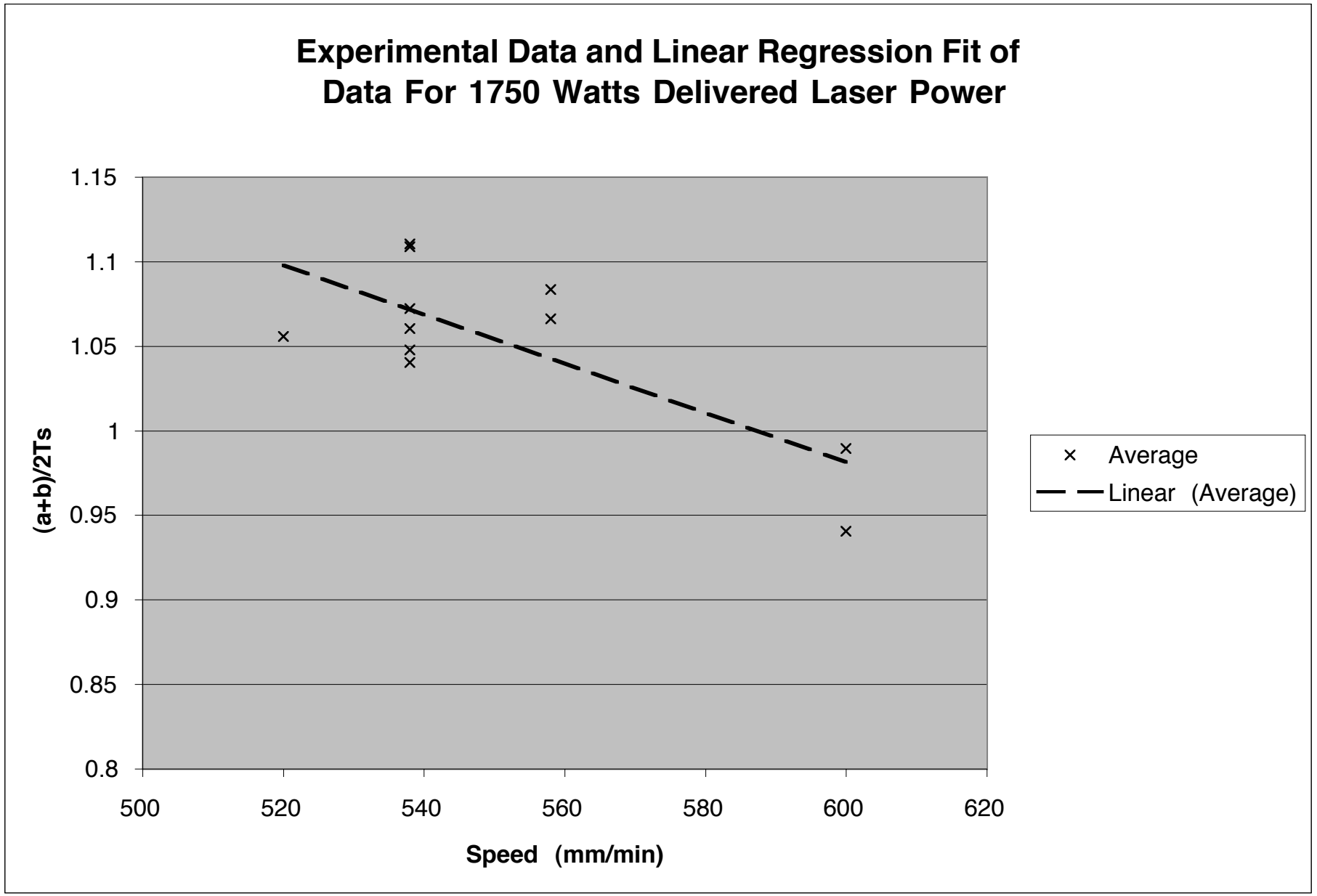

Experimental Data and Linear Regression Fit of Data For 1650 Watts Delivered Laser Power
(a+b)/2ts
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
500
520
540
560
580
600
620
Speed (mm/min)
Average
Linear (Average)

Figure 3


Experimental Data and Linear Regression Fit of Data For 1750 Watts Delivered Laser Power
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
(a+b)/2Ts
500
520
540
560
580
600
620
Speed (mm/min)
Average
Linear (Average)

Appendix A – Summary of Experimental Plan

Objective
To meet the requirements of the ASME VIII, Section UW 13.2(d). Section UW-13.2(d) requires that the weld meet a certain width and depth requirements in respect to the thickness of the material.

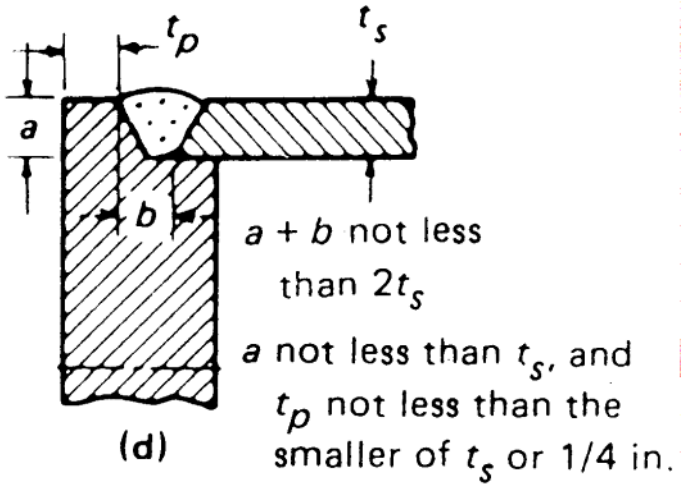
Method
Slow down the rotational speed of the can to allow the weld to become wider and deeper. This is done incrementally as laid out in Table A-1. At each setting three cans will be welded. Two cans will be sampled for metallogrophic examination and one can will be radiographed. The metallographic samples will be taken at three locations on each can. The locations will be in the weld overlap section ("O"), the narrowest weld width ("X"), and the typical weld width ("Y"). These sampled will be micrographed. From the micrographs, the values of a, b, t_s, and $(a+b)/t_s$ will be determined. The locations to measure a, b and t_s are defined in Figure A-1.

Table A.1

Day	Activity	Test Sample	Comments
1	1. Benchmark weld test	1	Verify acceptance
	2. Complete weld test at reduced can rotation speed of 580mm/min	3	2 metallographic sample, 1 radiographic sample
	3. Complete weld test at reduced can rotation speed of 560mm/min	3	2 metallographic sample, 1 radiographic sample
2	1. Assess results from previous day		
	2. Complete weld test at reduced can rotation speed of 540mm/min	3	2 metallographic sample, 1 radiographic sample
	3. Complete weld test at reduced can rotation speed of 520mm/min	3	2 metallographic sample, 1 radiographic sample
3	1. Assess results from previous day		
	2. Complete consistency trials at preferred rotation speed	4	2 metallographic sample, 1 radiographic sample

Figure A.1 Measurement method

1. Detail – ASME VIII Div 1, UW13.2(d)



Dimension ‘a’ - Depth of weld – lid radial surface to point of penetration into lid.

‘b’ - Weld width – Position of weld cap toe on lid radial surface to opposite point of weld intersection with lid radial recess/can interface.

‘t_s’ - Can thickness as measured

Appendix B - Experimental Results Table

#			Laser Power	Rotation Speed	Section Y		Section X		Section O		All Sections				
	Date	Can ID	Watts	mm/min	Angle . °	(a+b)/ 2ts	Angle. °	(a+b)/ 2ts	Angle. °	(a+b)/ 2ts	Ave.	Max.	Min.	W / speed	Comments
1	7/31/00	R300198	1637	600	50	0.96	316	0.91	252	0.92	0.93	0.96	0.91	2.73	Previous Runs
2	7/31/00	R300199	1637	600	50	0.97	316	0.91	252	0.97	0.95	0.97	0.91	2.73	
3	7/31/00	R300230	1637	600	50	0.94	316	0.93	252	0.97	0.95	0.97	0.93	2.73	
4	11/14/00	A000009	1637	600	158	0.95	271	0.87	46	1.00	0.94	1.00	0.87	2.73	Baseline Can
5	11/14/00	A000010	1637	579	215	1.00	297	0.88	25	0.94	0.94	1.00	0.88	2.83	580 mm/min Runs
6	11/14/00	A000012	1637	579	164	1.00	274	0.91	38	0.98	0.96	1.00	0.91	2.83	
7	11/14/00	A000017	1637	579	Radiography Can										
8	11/14/00	A000083	1637	558	145	0.99	265	0.90	40	0.97	0.95	0.99	0.90	2.93	560 mm/min Runs
9	11/14/00	A000086	1637	558	201	1.05	293	0.99	43	0.97	1.00	1.05	0.97	2.93	
10	11/14/00	R602242	1637	558	Radiography Can										
11	11/15/00	R602246	1637	538	258	1.02	180	1.03	60	1.02	1.02	1.03	1.02	3.04	540 mm/min Runs
12	11/15/00	R602250	1637	538	212	1.04	300	1.00	73	0.99	1.01	1.04	0.99	3.04	
13	11/15/00	R602251	1637	538	Radiography Can										
14	11/15/00	A000003	1637	519	290	0.98	180	1.08	65	1.03	1.03	1.08	0.98	3.15	520 mm/min Runs
15	11/15/00	A000014	1637	519	200	0.98	310	0.97	34	0.98	0.98	0.98	0.97	3.15	
16	11/15/00	A000076	1637	519	Radiography Can										
17	11/15/00	A000085	1755	558	180	1.05	294	1.06	40	1.09	1.07	1.09	1.05	3.15	560 mm/min + 100 Watt Runs
18	11/15/00	A000088	1755	558	250	1.13	151	1.05	50	1.07	1.08	1.13	1.05	3.15	
19	11/15/00	A000091	1755	558	Radiography Can										
20	11/15/00	R602240	1755	538	203	1.11	118	1.13	45	1.09	1.11	1.13	1.09	3.26	540 mm/min + 100 Watt Runs
21	11/15/00	R602247	1755	538	223	1.17	130	1.10	46	1.06	1.11	1.17	1.06	3.26	
22	11/15/00	A000093	1755	538	Radiography Can										
23	11/16/00	R602255	1755	538	169	1.01	265	1.09	55	1.08	1.06	1.09	1.01	3.26	Check of System after adjusting rollers
24	11/16/00	R602258	1755	538	285	1.09	154	1.06	52	1.06	1.07	1.09	1.06	3.26	
25	11/16/00	R602226	1755	538	Radiography Can										
26	11/17/00	R602230	1755	600	187	1.03	278	0.99	41	0.95	0.99	1.03	0.95	2.93	Run Automatic Mode, accidentally at 600 mm/min
27	11/17/00	R602418	1755	600	164	0.97	285	0.92	53	0.92	0.94	0.97	0.92	2.93	
28	11/20/00	R602186	1755	538	259	1.10	180	1.02	47	1.00	1.04	1.10	1.00	3.26	Run Automatic Mode at 540 mm/min
29	11/20/00	R602234	1755	538	297	1.04	230	1.04	50	1.07	1.05	1.07	1.04	3.26	
30	11/29/00	R602436	1755	520	154	1.04	265	1.07	43	1.06	1.06	1.07	1.04	3.38	Run Slower at 520 mm/min